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Acoustic reverberation data were acquired at the Blake Escarpment using the acoustic array of Naval Research Laboratory's Deep Towed Acoustic/Geophysical System (DTAGS). DTAGS is identical to the horizontally towed seismic streamers but has two collinear receiver arrays (acoustic and geophysics), and in addition it can be towed close to the sea floor in water depths to 5000 m. Although DTAGS acquired the two sets of data (acoustic and geophysics) simultaneously, only the acoustic array data are analyzed for this reverberation study. The geophysics data are independently used for bottom and subsurface mapping and are not discussed further.

The data is studied using the time-intercept ray parameter (*t*-*p*) technique to isolate the grazing angles (and corresponding bottom features) with the largest contributions. The contributions are separated into those associated with specular returns, and those associated with largely incoherent backscattering. These data are further analyzed to study the reverberation processes

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LOW FREQUENCY, BROADBAND MEASURED REVERBERATION LEVELS AT INTERMEDIATE TO HIGH GRAZING ANGLES AT BLAKE ESCARPMENT

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INTRODUCTION

Acoustic reverberation data were acquired at the Blake Escarpment using the acoustic array of Naval Research Laboratory's Deep Towed Acoustic/Geophysical System (DTAGS). DTAGS is identical to the horizontally towed seismic streamers but has two collinear receiver arrays (acoustic and geophysics), and in addition it can be towed close to the sea floor in water depths to 5000 m. Although DTAGS acquires the two sets of data (acoustic and geophysics) simultaneously, only the acoustic array data are analyzed for this reverberation study. The geophysics data are independently used for bottom and subsurface mapping and are not discussed further.

The data is studied using the time-intercept ray parameter (τ-p) technique to isolate the grazing angles (and corresponding bottom features)with the largest contributions. The contributions are separated into those associated with specular returns, and those associated with largely incoherent backscattering. These data are further analyzed to study the reverberation processes.

FIELD ACQUISITION PARAMETERS FOR HORIZONTAL ARRAY

As mentioned earlier, the DTAGS acquires data with two collinear horizontally towed (acoustic and geophysics) arrays. The geophysics array is towed behind the acoustic array which has a near offset distance of 72 m from the source. Each array consists of 24 channels and each channel is a group of 6 elements, 0.6 m apart. The channel separations in acoustic and geophysics arrays are 2.1 and 21 m respectively, and the acoustic and geophysics data are recorded simultaneously. The DTAGS source is an omnidirectional, 205 dB, 250 to 650 Hz, LFM resonator (marine vibrator).

In order to acquire intermediate to high grazing angle, backscattered reverberation data, the DTAGS was towed at a distance of 400 m to 2000 m from the sea floor during the approach , and transversing of the Blake Escarpment. The acoustic array data will consist of the intermediate grazing angle backscattered reverberations as well as the high angle backscattered and specularly reflected data. We studied the application of time-intercept ray parameter (τ-p) technique on data DTAGS that was acquired during Blake Escarpment sea exercise.

TIME-INTERCEPT RAY PARAMETER (τ-p) PROCESSING TECHNIQUE

The time-intercept ray parameter (τ-p) processing technique discriminates on the basis of the apparent velocities (v_a) of the plane wavefront recorded at the receiver arrays.

Consequently, there is an inherent assumption that the data recording is done in the far field region.

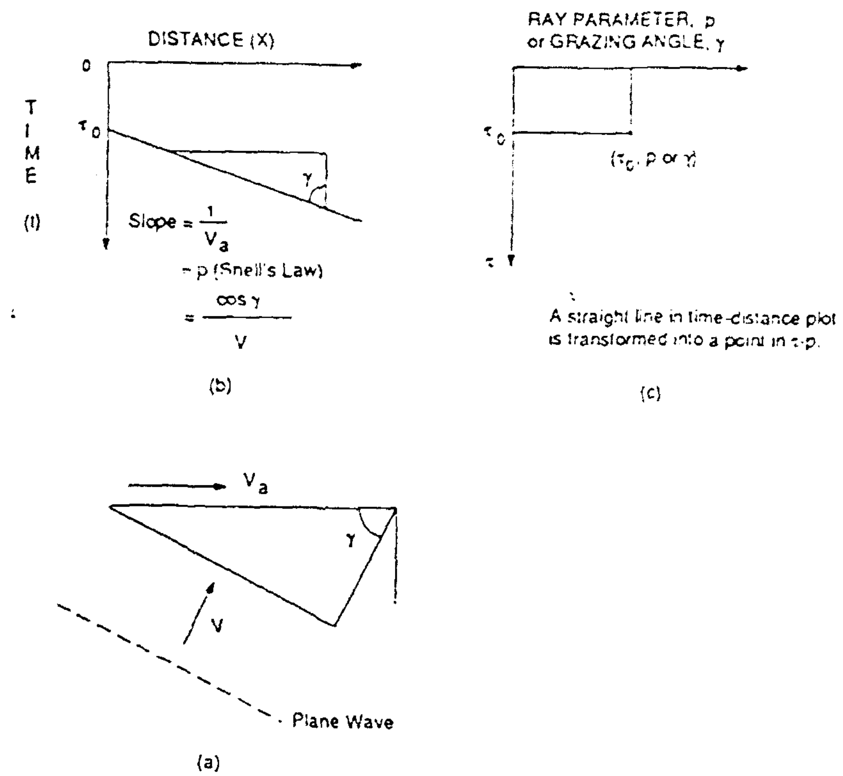


Figure 1

Refering to Figure 1 (a), the plane wavefronts, travelling at the medium velocity v, arrive at the recording array at a grazing angle γ. The apparent velocity of the waves along the recording array, v_a, is given by:

$$v_a = v\,(\cos\gamma)^{-1} \qquad (1)$$

The time-distance plot of the plane wavefront arrivals, is a straight line whose slope is the inverse of the apparent velocity as indicated in Figure 1 (b). Consequently, we can write its equation as

$$t = \tau_0 + x(v_a)^{-1} \qquad (2)$$

where τ_0 is the time-intercept and is the time taken to travel from the initiation of the source to the first element of the recording array. From Snell's law, we have that

$$\text{ray parameter } p = (\cos\gamma)\, v^{-1} = (v_a)^{-1} \qquad (3)$$

Consequently, we can write the equation of the straight line in terms of the ray parameter p

$$t = \tau_0 + px \qquad (4)$$

where the ray parameter p is the slope of the straight line, and it represents the direction of arrival (DOA), γ, as given by (3) above.

A straight line is characterized by its slope (p) and the time-intercept (τ_0). In τ-p technique, one transforms a straight line into τ-p domain by plotting the sum of the responses along the line against its slope (p) and the time intercept (τ_0). As a result, a straight line in time distance domain is transformed into a point in the τ-p domain as shown in Figure 1 (c). The summation along the horizontal line (p=0) is the special case of a linear array response, where all the individual receiver responses are summed together with no delays and enhances the vertical arrival event (±90).

By this transformation, we decompose the time-distance data into planewaves and the process is correctly called 'planewave decomposition'. As mentioned above this transformation is obtained by summing or stacking the data along sloping or slanting straight lines, and so this process is also known as the slant stacking in exploration geophysics.

The slope p is the measure of the DOA, γ, according to (3), and consequently, one can also convert the p-axis into the DOA angle axis or grazing angle (γ) axis as indicated in Figure 1(c). The transformed γ axis will, in general, represent all angles from -90 to +90°. We can retain the traces representing the angles of interest and reject those not of interest, for further processing.

The mathematical representations of the τ-p transform and its inverse are given by the following (Clarebout, 1985):

$$U_R\ (\tau, p) = \int U\ (x,\ \tau + px)\ dx$$

$$u\ (x,t) = t^{-2} * \int U_R\ (p,\ t - px)\ dp$$

where * represents the convolution operation.

BLAKE ESCARPMENT DATA AND ITS PROCESSING

We have acquired a set of data corresponding to a transverse of the Blake Escarpment in the area indicated in Figure 2 (a). During the transversal of the escarpment the source and receiving arrays were towed at depths ranging from 2830 meters to 2491 meters below mean sea level. During the experiment the system was towed at 1.6 to 2 kts along a track that brought it within 400 meters of the escarpment (Rowe and Gettrust, 1990).The source was activated every 30 seconds, with a resultant average shot spacing of 25 meters. Figure 2 (b) shows the bathymetry beneath the DTAGS system.

LOW FREQUENCY, BROADBAND MEASURED REVERBERATION LEVELS

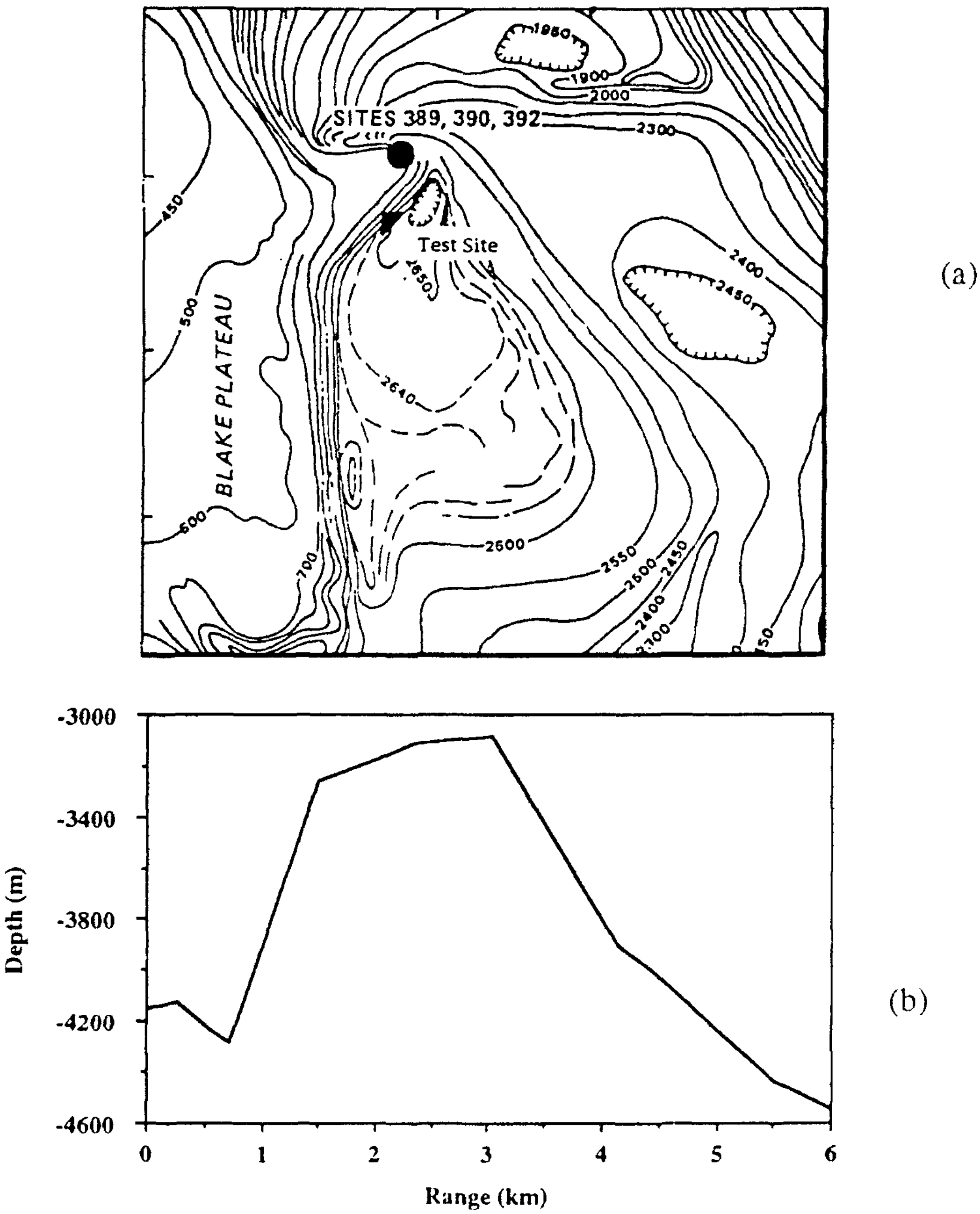


Figure 2. Bathymetry plot (a) of test site showing nearby DSDP sites, and bathymetry along ship track (b) derived from geophysics data.(Contour plot derived from Initial Reports DSDP Volume XLIV).

The geological interpretation of the region was extracted from the DSDP report from the three drill sites located in the experiment area. This includes core samples and derived information necessary to compute plane wave reflection coefficients.

The data was originally sampled at 3125 samples per channel per second. The possibility of spatial aliasing was reduced by band pass filtering the original 250 to 650 Hz FM pulse to a band from 250 to 355 Hz, corresponding to the receive aperture. The resampled data were then deconvolved, and processed using the τ-p process.

The received angles were then associated with a grazing angle on the escarpment using a simple range dependent ray tracing algorithm. This allowed direct comparison of the observed receive angle with known bathymetry.

RESULTS AND INTERPRETATION

Figure 3 shows the processed time record for ping 17. Ping 17 occurs at an approximate range of 425 meters (refer to figure 2(b) for orientation), with forward direction toward the escarpment. It indicates the presence of the strong specular and near specular returns. Figure 4 shows the time intercept record for the ping. Ray path analysis predicts that event # 1 from ping 17 is a normal incidence arrival. The calculated bottom loss for this path is 3 dB, which agrees with a plane reflection coefficient based on the geology. Event # 2 is interpreted as a backscattering event that comes from the flatter region which starts at a depth of 3200 m (see Figure 2 (b)). The grazing angle at the sea floor is 20°, and the scattering strength (based on sonar equation methods) is -40 dB per square meter.

Figure 5 shows the frequency response for event #1, and Figure 6 shows the frequency response for event # 2. In producing these response curves the transmission loss effects were not removed. The basic shape of the response curves is similar, with the expected lower signal to noise ratio for the backscattered event.

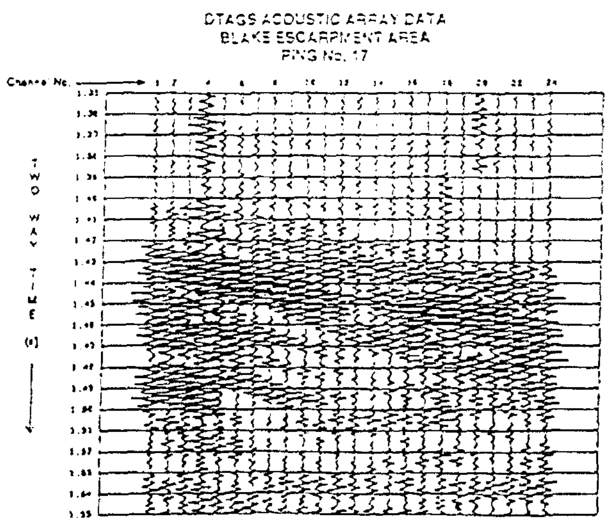


Figure 3.

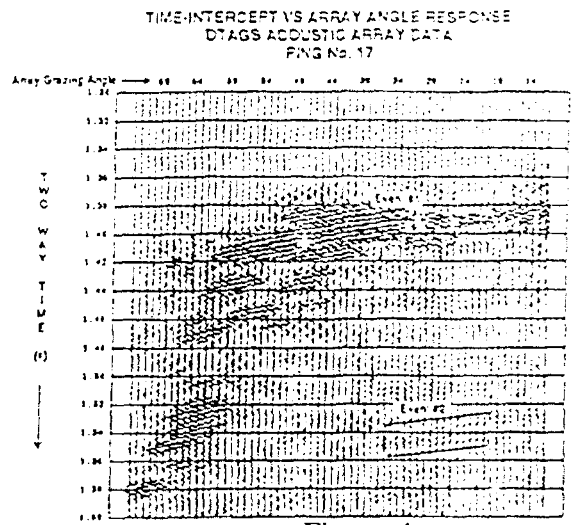
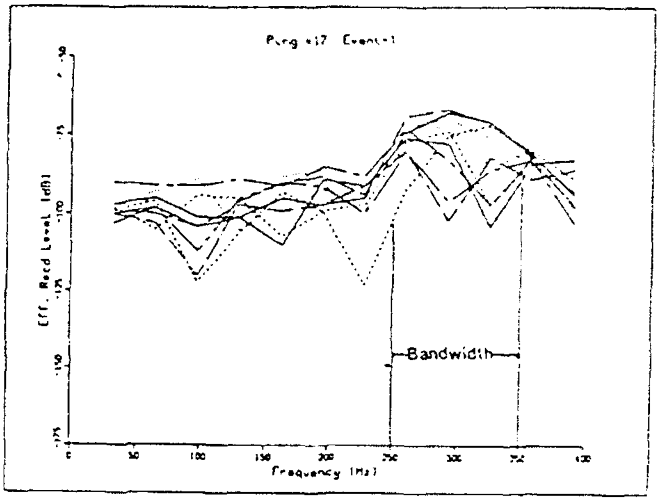


Figure 4.

LOW FREQUENCY, BROADBAND MEASURED REVERBERATION LEVELS

Figure 5.



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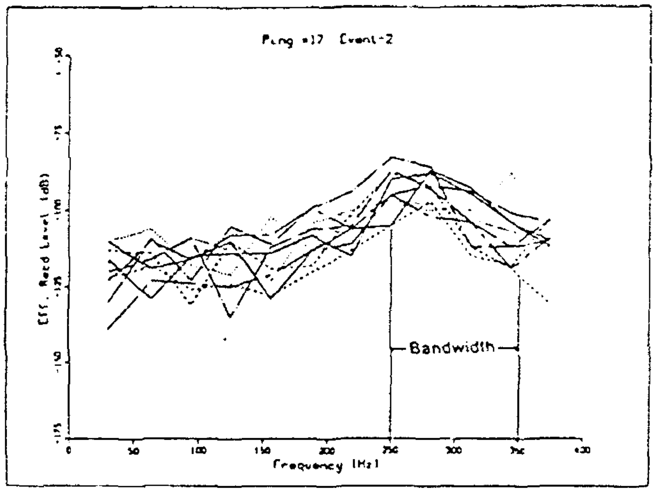

Figure 7 shows the processed time record for ping 104. Ping 104 occurs at at approximate range of 2910 meters (refer to figure 2(b) for orientation), with forward direction to the right. It indicates the presence of the strong specular and near specular returns. Figure 8 shows the time intercept record for the ping. Ray path analysis predicts that event # 1 from ping 104 is a normal incidence arrival. The calculated bottom loss for this path is 4 dB, which agrees with a plane reflection coefficient based on the geology. Event # 2 is interpreted as a backscattering event that comes from behind the system. The grazing angle at the sea floor is 45°, and the scattering strength (based on sonar equation methods) is -35 dB per square meter.

Figure 9 shows the frequency response for event #1, and Figure 10 shows the frequency response for event # 2. The two responses are similar to that observed for ping 17.

LOW FREQUENCY, BROADBAND MEASURED REVERBERATION LEVELS

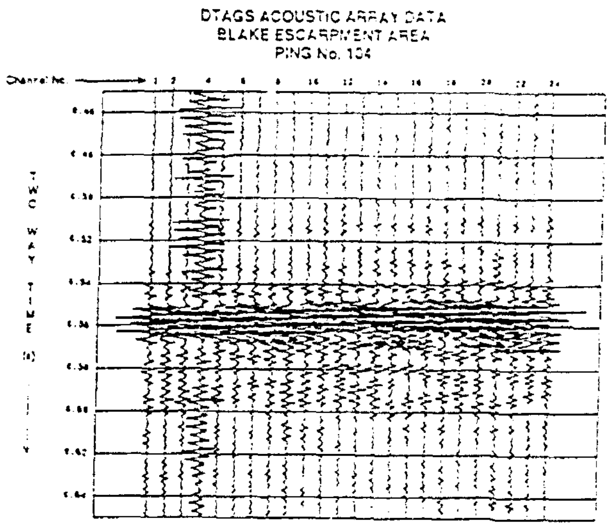

Figure 7.

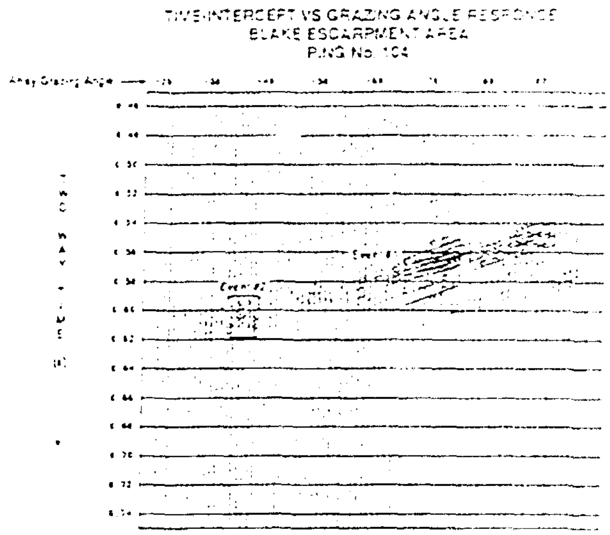

Figure 8.

CONCLUSIONS

Based on the towed array data we have shown that the time intercept-ray parameter (τ-p) technique was effective in allowing segments of the data to be identified with paths known to be specular, and paths that give rise to low level backscattering. The backscattering levels deduced from this technique lie within the expected bounds.

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REFERENCES

Clarebout, Jon F. (1985) Imaging the Earth's Interior, Blackwell Scientific Publications.

Initial Reports of the Deep Sea Drilling Project. Volume XLIV Norfolk, Virginia to Norfolk, Virginia August-September 1975. National Science Foundation. NSPSP - 44.

Rowe, M. M., and J. F. Gettrust (1990) Preliminary Analysis of Low-Frequency Backscatter Data from the Blake Escarpment. Naval Oceanographic and Atmospheric Research Laboratory, Stennis Space Center, MS. Technical Note 39.

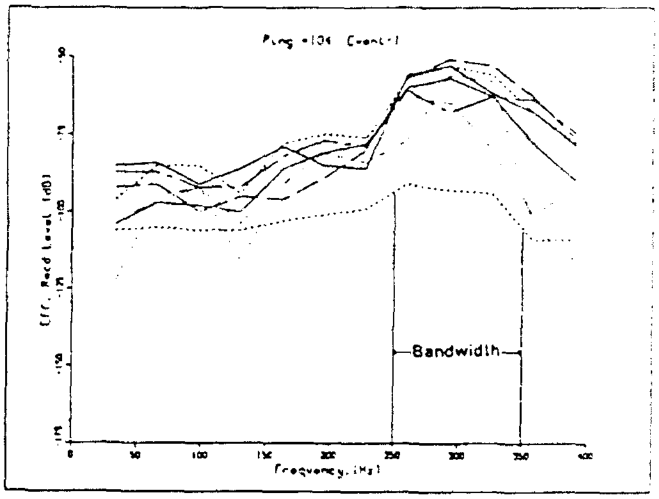

Figure 9.

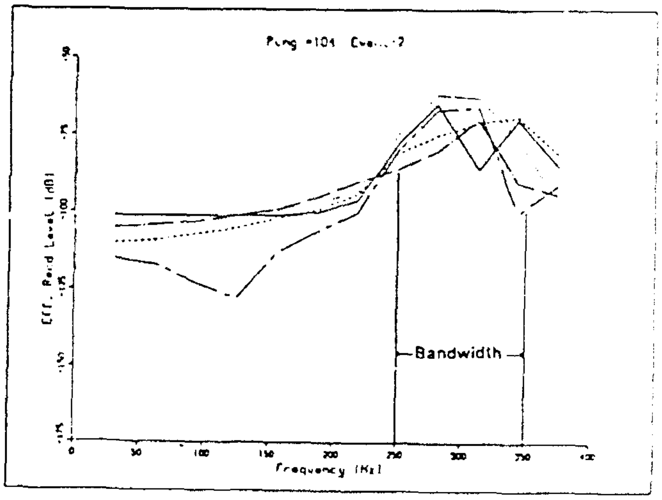

Figure 10.